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Potato Scab and Its Prevention

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BULLETIN No. 85: POTATO SCAB AND ITS PREVENTION[1]

By L. R. Jones and A. W. Edson

I. SUMMARY

The potato scab is caused by a fungus, which also causes scab on beets and possibly on the roots of other vegetables. Pages 112-113

The fungus is probably not a native of our soils. Its germs occur in great numbers on scabby potatoes, and may cling to the surface of smooth tubers. Much of the loss from scab is directly due to the use of infected seed. When the fungus is not present in the soil a clean crop is assured if clean seed is used. Pages 113-115

Soil conditions may be favorable or unfavorable to the development of the scab. Pages 115-116

Certain varieties of potatoes are more liable to scab than others. Page 116

Prevention or control should aim at the selection of resistant varieties, keeping the soil free from the fungus and disinfecting the seed potatoes. Page 117

It is cheaper to abandon potato growing upon badly infected soil for a time than otherwise to combat the pest. If soil is free from the fungus any method of fertilizing is safe, but if infected, alkaline fertilizers are to be avoided Chemical disinfection of soil is not effective enough to warrant the cost. Pages 117-118

Seed potatoes are disinfected either by soaking one and a half hours in a solution made by dissolving 1 ounce of corrosive sublimate in 7 gallons of water; or by soaking two hours in a solution made by diluting one-half pint of formalin in 15 gallons of water. Pages 118-119

Formaldehyde gas gives considerable promise of being an effective and convenient disinfectant. Other methods of disinfection are prolonged exposure to sunlight, using sulphur in the row, and fumigating with sulphurous gas. Page 119-120

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1 The results of the investigations at various other experiment stations have been drawn upon freely in the preparation of this bulletin. A list of the more important bulletins and reports of other stations dealing with potato scab follows:

Beckwith, M. H., N. Y. (Geneva) Sta. Rpt. 6, pp. 307-344 (1887).

Humphrey, J. E., Mass. Sta. Rpt. 6, pp. 131-138 (1888); Rpt. 7, p. 214 (1889.)

Thaxter, R., Conn. Sta. Rpt. 14, pp. 81-95 (1890.)

Bolley, H. L., N. Dak. Sta. Bul. 4 (1891); Bul. 9, pp. 27-41 (1893.)

Wheeler, H. J., R. I. Sta. Bul. 33 (1895); Rpt. 10, p. 254 (1897.)

Arthur, J. C., Ind. Sta. Bul. 65 (1897.)

Halsted, B. D., N. J. Sta. Bul. 120 (1897); Rpt. 20, pp. 324-345 (1899.)

II. OCCURRENCE AND APPEARANCE

Occurrence.—Scab is the commonest and most widespread disease of potatoes in America. It occurs also in Europe and probably wherever the potato is grown. The same disease attacks the roots of the various varieties of beets. A scab disease similar in appearance, and possibly identical in cause with that of potato and beet, occurs on the roots of some other garden vegetables, including turnip, radish, cabbage and carrot.

The financial loss to potato growers from the scab is difficult to estimate. It often ruins a considerable portion of the crop for table use, and when it is abundant on the tuber it probably checks its growth and so reduces the yield. In one experimental field at the station farm the past year every potato was covered with scab. The only use to be made of such a crop is for stock feed or the starch factory, and in either case the value is small. The scab does not appear to affect the flavor or the cooking qualities of potatoes, but it renders them so unsightly and makes their preparation for the table so troublesome and wasteful that even a small amount of the scab on a crop seriously reduces its market value. It may also destroy the keeping quality of the tubers, scabby potatoes being especially liable to soft rot in the field and cellar.

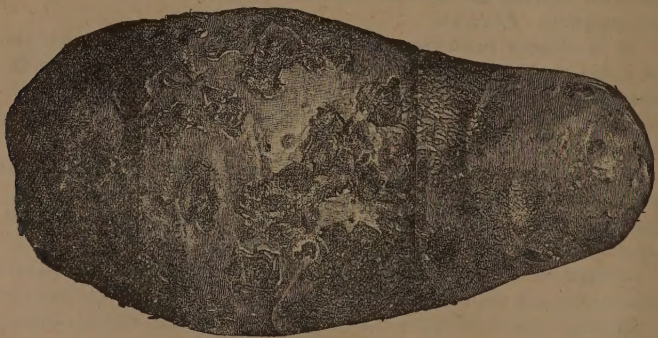

Fig. 1. POTATO AFFECTED WITH SCAB

From Galloway, Farmers' Bulletin 91, United States Department of Agriculture

Appearance.—Scabby potatoes are so common that a detailed description of the disease is unnecessary. The illustration, figure 1, shows the familiar blackened pocket-like cavities and roughened corky spots characteristic of the scab. Other imperfections, abnormal developments, or injuries caused by insects frequently occur on the surface of the potato, but these are easily distinguishable from the characteristic scab-spots. The appearance of the scab as it develops in the beet is well shown in figure 2. This also is a familiar thing to gardeners. The scab here does not lead

to pits but results in rough, corky elevations which are usually more extensive on the upper half of the root as is shown in the figure.

III. CAUSE

Historical.—The cause of potato scab was a much debated question up to ten years ago. Potato growers, according to their individual experiences, attributed it to one or another condition of seed, or soil, or to parasites. One man said it was due to too rich soil, another to clay, another to moisture, another to manure; many were of the opinion that it was due to wire worms, grubs, millipeds or some other form of insect life. It was often suggested that the trouble started with scabby seed, but long continued observations at the New York and the Massachusetts experiment stations had failed to establish even this fact previous to 1890.

Scab a germ disease.—This was suggested in 1842, but it was not until 1890 that Dr. Roland Thaxter, then botanist of the Connecticut experiment station, proved that the first cause of the scab spots on potato is a fungus. If one examines the young developing scab spots on half-grown potatoes, freshly dug and still moist, the surface of each spot may be found covered with a delicate filmy white mould growth barely visible to the naked eye. It is this fungus growth eroding and irritating the potato tissues which causes the scab spot. The fungus produces vast numbers of minute spores in the course of its development. Many of these will remain in the soil of the potato field and so perpetuate the fungus, even though no potatoes are grown there for many years (see page 115). Countless numbers of dormant spores are probably carried from the field in the scab spots, and, falling from these as the spot dries out, become mingled with the dust which clings to the surface and lodges in the eyes of even the smooth tubers that have been in contact with the scabby ones in the field or the storage bins.

Fig. 2. POTATO SCAB ON BEETS
From Farmers' Bulletin 56, United States Department of Agriculture

It was thought a few years ago that there were two forms of potato scab, the more common deep scab caused by the above described fungus and a surface scab caused by bacteria. This has not been demonstrated, however, and, since the remedial treatment would be the same in either case, it is a matter of theoretical rather than of economic interest.

Insects in relation to the scab.—A certain insect called the potato scab gnat has been found in West Virginia, which inhabits the scab spots and causes one form of this malady. Insects of other kinds are sometimes found in scab spots and may by their activities increase the size or depth of the spots. In all cases, however, so far as observed in the northern states, these insects are secondary, and when the scab fungus is absent the insects alone never cause the disease.

IV. DEVELOPMENT AND SPREAD

The scab fungus like most other fungi appears capable of very rapid development and reproduction under favoring conditions; but, on the other hand, it is very sensitive in regard to its environment. The germs may occur in abundance in the soil or on the seed potatoes, and yet lead to little scab on the crop if soil conditions do not favor; whereas, under favoring conditions, a comparatively few germs on the seed or in the soil may cause great damage. A clear understanding of the conditions governing the development of the scab is, therefore, necessary to a successful fight against it.

Presence of germs.—In the absence of the germs there can be no scab. This is settled beyond question. Bolley of the North Dakota experiment station states positively as a result of his experiments that neither clay, the blackest muck, nor any other germ-free soil that he tried led to scab. On the other hand the development of scab spots was visible within from three to ten days after the germs were applied to the surface of young tubers. These germs do not originate spontaneously. The evidence indicates that the fungus is not a native to our soil. It probably was brought here along with the potatoes in the early days of their culture. Whatever the original source of the scab fungus, there is no doubt that its introduction and further spread in our fields at the present time is largely *by means of contaminated seed potatoes*. It may be carried occasionally on beets or other roots, or with manure, or on tools; but these agencies are probably of minor importance. Our experience in growing potatoes experimentally during four seasons on a recently cleared wood lot where no other crop has ever been grown has shown that in such virgin soil the scab on the crop comes from scabby seed. Trials at the New Jersey station proved that when scabby potatoes were spaded into the soil in the autumn there was a large increase in the amount of scab in the crop

grown on that soil the next year. A still more important experiment conducted at the same time was one in which the scabby potatoes were fed to young cattle and the manure from these animals used in the potato field. It is of much practical interest that there was no increase in the amount of scab in the latter case. A single trial of this kind cannot be considered conclusive, but it indicates that cow manure is not a carrier of the germs of the disease, and that scabby potatoes may safely be disposed of by feeding them to cattle.

How long may the scab fungus persist in the soil?—This is a question of much practical importance. It is a matter of common observation that if the scab gets started it will persist if potatoes are grown continuously on the same ground year after year. We have been forced to abandon potato culture on one field at the experiment farm for this reason. We planted some scabby seed there for an experiment in 1898, and there was some scab in the crop. Disinfected seed was planted on this piece in 1899, yet there was more scab than in 1898. We carefully disinfected the seed again in 1900 and planted five rows across the same field. Every tuber was badly scabbed. How soon will it be safe to plant potatoes on this soil again? It is not known, and probably will depend much on soil conditions and intervening crops. In another experiment last year disinfected potatoes were planted on a soil where no potatoes, beets or other root crops had been grown for seven years at least, and probably longer; yet in parts of the field over fifty per cent of the crop was scabby. Bolley found beets badly scabbed the fifth year after a potato crop with no reason to believe that the germs had been reintroduced meanwhile. Halsted's experiments at the New Jersey station have convinced him that the scab fungus "is actively retained in the soil for at least six years without the presence of potatoes or beets," although it is to be observed that in this field turnips were the intervening crop and may have harbored the fungus.

Soil conditions.—Every potato grower knows that some soils are more favorable to scab than others. General experience indicates that heavy soils, whether they are of clay, muck or humus, are of the favoring class. This may be because they are moister. There is ground for the statement sometimes made that the soil best fitted for a large yield of potatoes is also most inclined to scab.

Experiments made at the Rhode Island station show that an acid condition of the soil checks the development of the scab fungus. Reasoning from these results, Wheeler suggests that plowing under of a green crop, as of clover, on contaminated land will check the development of the scab fungus, since this green matter while decomposing will render the soil temporarily acid. This opinion is in accord with the favorable experience of of those who plant potatoes on clover sod. On the other hand, fertilizers

or manures which tend to destroy the natural acidity of the soil or to increase its alkalinity may thereby render conditions more favorable for the fungus. It is the common experience that lime and ashes are apt to favor the scab. The Rhode Island experiments showed that this is attributable to their content of carbonate of lime which renders the soil favorably alkaline. Similar increase of scab followed the use of soda ash (carbonate of soda), potash (carbonate of potassium) and magnesia. Stable manure of all kinds favors the scab development, probably for similar reason.

Fertilizing materials which do not tend to increase the scab and which may even check it are enumerated as follows: common salt, land plaster, most commercial fertilizers (including superphosphates,) sulphate of ammonia, nitrate of soda, kainit, muriate of potash, sulphate of potash.

Resistance of varieties.—Students of plant diseases are agreed that during recent years there has been a tendency to place too little emphasis upon the importance of the selection and use of the more hardy or disease-resistant varieties of plants. Potato growers generally recognize that there is a wide difference in the relative liability of the sundry varieties to the scab, as well as to blights and other diseases. But we have had few systematic tests from which to learn the facts more exactly. Halsted has recently tested seven varieties in respect to liability to scab and ranks them in the following order, beginning with the most susceptible: (1) Early Rose, (2) Delaware, (3) June Eating, (4) Queen, (5) American Giant, (6) Rural Blush, (7) Rural New Yorker, No. 2. Our own experience at the Vermont station with some of these varieties is in harmony with Halsted's; thus in our experiments in 1900 with Delaware and Rural New Yorker the former scabbed much worse than the latter when grown under similar conditions.

Mr. A. E. Manum of Bristol, a potato breeder of long experience, writes as follows in reply to an inquiry as to his opinion upon this subject:

"I have observed that some varieties are more susceptible than others. Such smooth, white, thin skinned potatoes as the Sir Walter, Uncle Sam and the Enormous are less affected than such varieties as State of Maine, Bristol Beauty, Burbank, Bovee's Early, Polaris and Pride of the South. I have observed, also, that potatoes with rough skin are much more exempt than the smooth skinned varieties. Last season I planted about 400 seedlings which were from one year to five years from the seed bulb. I dug these potatoes myself and found that some were more scabby than others, the rough skinned varieties being nearly all exempt. Some of the smooth skin varieties in the same row, and next to the rough ones, were very scabby. In one row that was made up of several varieties, nine hills of each, one variety was free from scab while the nine hills on either side were quite scabby. While digging the piece I found other instances nearly as marked as this one."

There is need for more of such investigation looking to the determination of the resistance of varieties and the cause of such resistance.

V. PREVENTION

In view of the facts developed as to the cause of potato scab it is evident that remedial measures should aim at one or more of the following things:

1. To produce or select varieties which are more resistant to the scab.
2. To keep the soil free from the fungus.
3. To render an infected soil unfavorable to fungus development.
4. To kill the fungus germs which adhere to the seed potatoes.

The first of the above propositions, as has been already remarked on the opposite page, is a matter of much importance.

The other remedial treatments may best be discussed under two heads: (1) Soil treatments; (2) Disinfection of seed.

SOIL TREATMENT

Rotation of crops.—When the soil has become badly infested with the scab fungus it is usually cheaper to abandon potato growing upon it for a time at least than to continue the practice. The best system of croping to purify such a soil and the length of time which should elapse before potatoes may be grown again with safety is not fully determined. The evidence indicates that root crops should be avoided, and that grains, including corn, grasses, and especially clover, are the best cleaning crops. The turning under of a green crop, like clover, just before potatoes are again planted is especially commended for reasons cited on page 115.

Fertilizing.—In case the soil is free from the scab fungus and clean seed is used any method of fertilizing is safe. The only exception may be that of stable manure from animals fed on scabby potatoes, but the experiment referred to on page 115 indicates, but does not prove, that manure from cattle fed on scabby potatoes may be used with safety.

In case the germs are already present in the soil, or on seed potatoes, stable manure and certain alkaline fertilizing substances which favor the development of the fungus are to be avoided. These substances include ashes, lime (either quick or air-slaked), soda-ash (carbonates of soda), potash (carbonate of potassium) and magnesia. On the other hand, certain fertilizing elements which are not favorable to the fungus are to be commended. These include land-plaster (sulphate of lime), common salt, nitrate of soda, kainit, muriate of potash, sulphate of potash, sulphate of ammonia, superphosphates and most commercial fertilizers. Instead of stable manure applied directly to the potato crop, clover should be grown and the potatoes planted on the clover sod. There would probably be even less objection to the use of the stable manure on some crop like corn, which preceded the clover.

The use of sulphur and other chemical disinfectants.—Many chemical disinfectants have been tried on contaminated soil in the hope that the soil might be purified by this method. These trials have included direct applications to the soil in varying amounts of bordeaux mixture, corrosive sublimate, formalin, potassium sulphide, carbolic acid, copper sulphate and sulphuric acid, but in none of these cases has there been appreciable benefit. The one chemical which has proved promising for use in this way is flowers of sulphur. Experiments at the New Jersey station have led Halsted to believe that an application in the drill at planting time of three hundred pounds of sulphur to the acre will check the scab even in an infected soil. Others trying this same method have had varying results. At the Rhode Island station even six hundred pounds of sulphur to the acre was found to be practically useless. Last summer at this station sulphur was applied in a drill at the rate of four hundred and seventy-five pounds to the acre on soil that was known to be badly contaminated. Moreover, disinfected seed was used, yet the result was a crop in which *every potato was badly scabbed.* We are convinced, therefore, that flowers of sulphur is at best an unreliable remedy and not to be recommended. Its excessive cost—ten dollars or more to the acre—practically prohibits its use.

DISINFECTING SEED POTATOES

Where the soil is free from the fungus the practical remedy for the scab is the disinfection of the seed tubers. The object is to kill the germs clinging to the tubers without injuring the tuber itself. This can be done more or less successfully in different ways. Soaking the seed tubers in a solution either of corrosive sublimate, or of formalin is a method now used by many practical potato growers. Other remedies have been discovered, the value of which has not been so thoroughly demonstrated, but which may prove preferable, at least in some cases.

Corrosive sublimate treatment.— Corrosive sublimate, or bichloride of mercury is a white crystalline substance, resembling salt, which can be bought from any druggist. To make the solution, place one ounce of this chemical in one gallon of hot water and after allowing it to stand ten or twelve hours until dissolved, dilute with more water to make seven gallons. This solution should be made in wooden or earthen, rather than metal, dishes, since it corrodes metals. The seed potatoes are to be soaked one and one-half hours in the solution. The disinfection may be done at any convenient time previous to planting. In fact, after experimental use of this solution for several years we are led to recommend that the disinfection be done several weeks before planting, since it may retard germination somewhat when used just before planting.

In using this solution it must be remembered that it is *deadly poisonous to men and animals if taken internally.* It is not poisonous to the skin, how-

ever, so that one may handle the solution or the treated seed with impunity. All tubers soaked in it should be planted, buried or burned.

Corrosive sublimate costs 15 cents an ounce. Since the same solution can be used over and over again indefinitely the expense for disinfection other than labor is but a trifle. The chief disadvantages in the use of corrosive sublimate as compared with the next remedy, formalin, are two-fold: first, its poisonous nature; and second, the difficulty of dissolving it.

Formalin solution.—Formalin is a watery liquid, also known to the trade as formaldehyde solution. It is used with potatoes, at the rate of eight ounces (one-half pint) of the commercial formalin to fifteen gallons of water. The seed potatoes are soaked two hours in the solution. If this method is used, it is better, according to our experiments, to disinfect the seed not more than a few days before planting. Corrosive sublimate and formalin have in our comparative trials during the last three years given equally good results as remedies for the scab. The chief advantages of formalin are that it is not poisonous and, being a liquid, it is easily diluted for use and may be placed in any kind of a receptacle. It is, therefore, considerably more convenient than is the corrosive sublimate. Another fact in favor of the formalin is that it does not injure the seed-tubers or retard their germination as does the corrosive sublimate in some cases. Formalin costs from forty to fifty cents a pound (pint). It is therefore a little more expensive to use than is corrosive sublimate but the cost of the chemical is a small matter in either case. One pound of the formalin costing fifty cents will make thirty gallons of the disinfecting solution. This can be used to disinfect fifty bushels of potatoes, or more if care is taken. Probably this solution will slowly lose strength upon standing so that it is desirable to keep a close cover on the barrel or other receptacle if it is to be used repeatedly. We have never used the same solution for immersing more than five or six successive lots of tubers although we do not doubt that with care it might be used for more.

A convenient way to use either of the above solutions is to make them up in a large barrel or tub. The potatoes may then be placed in a coarse sack and suspended in the liquid. Some prefer to place a faucet or spigot at the bottom of barrel. The barrel is then filled with the potatoes and enough of the solution added to cover them. At the end of the period of soaking the solution is drawn off and the potatoes emptied out. After soaking the potatoes may be cut and planted at once in the usual way or they may be allowed to dry and again be placed in storage until planting time. In any case care must be taken that they are not reinfected by contact with bags or boxes in which scabby potatoes have been kept.

Formaldehyde gas.—The active disinfecting agent in the formalin solution is a gas known as formaldehyde which is dissolved in the water. The value of this gas for disinfecting hospitals, sick rooms, and other places

where a gaseous germicide is desired, has been fully demonstrated. It seems probable, therefore, that fumigating the seed potatoes with the gas itself instead of soaking them in the liquid, might prove a practical method of disinfecting them. If so, it has manifest advantages over the method of soaking. We tried fumigation last season using a formalin lamp.[1]

We placed one-half bushel of exceedingly scabby tubers in an air tight box having a capacity of eight cubic feet. One-half of one of the formalin tablets sent with the lamp (i. e. ½ gram) was heated in the lamp according to the directions given, and the box was kept closed for six hours thereafter. Of course we were unable to draw positive conclusions from a single experiment so limited as this one; but in the field in which this experiment was made this fumigation method gave the best results of any treatment under trial, being superior to both the formalin and the corrosive sublimate solutions.[2] The use of formaldehyde gas as a disinfectant for scab is still in the experimental stage, but the indications are that it may have great practical value, especially for the larger growers and seedsmen.[3]

Other methods.—A simple and quite effective method of disinfection is to expose the seed tubers to sunlight[2] for several weeks previous to planting. We used this method last season for disinfecting seed, every tuber of which was exceedingly scabby. Upon harvesting the crop from this seed we found only 16¾% scabby as compared with 45½% in untreated rows. Where seed is not badly or deeply scabbed, sunlight would no doubt be entirely sufficient. The value of this treatment is the greater since exposure to sunlight hastens the growth of the tubers. Indeed it is often practiced for this reason alone. Our potatoes so treated were up a week ahead of any of the others.

Rolling the seed in sulphur and scattering sulphur in the row has been found to check the development of the scab. We have tried this method but have found it distinctly inferior to any of the preceding methods. Since it is also inefficient in preventing the development of scab germs in the soil and is quite expensive, its use is not to be recommended.

Burning a small quantity of sulphur in the storage cellar has been recommended to kill the scab germs. This method would certainly be very convenient and inexpensive if it should prove efficient. Our own trial of it made in 1900[2] was inconclusive, so we are not at present in a position either to recommend or to condemn it.

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1 This lamp was obtained from Schering & Glatz, 55 Maiden Lane, New York City. It consists essentially of an alcohol lamp and a reservoir to receive the tablets which generate the formaldehyde gas when heated. The outfit is very simple and it is accompanied by full directions and a package of forty of the one grain tablets or pastilles. Price $1.75.

2 For further details regarding the experiments with formaldehyde gas, disinfection by sunlight, and the use of sulphur fumes, see Vt. Sta. Rpt. 13, pp. 275-276 (1900).

3 Formalin diluted with water, or from which through careless storage the gas has vaporized, has been sold in Vermont. Such is not useful. Samples sent to the station will be examined as to their strength without charge.